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FLOOD INSURANCE STUDY

WAVE HEIGHT ANALYSIS

ORIGINAL

COMPLETED
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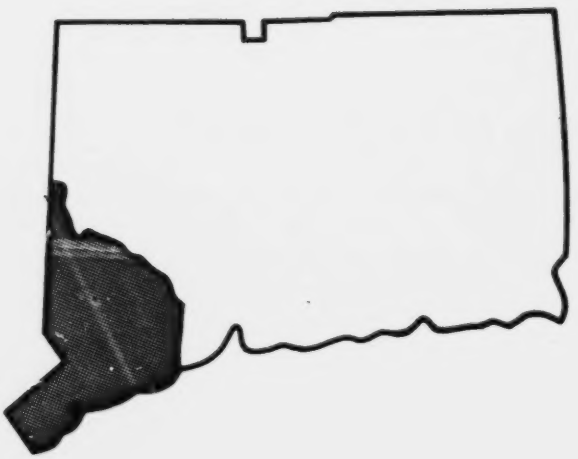
TOWN OF DARIEN, CONNECTICUT
FAIRFIELD COUNTY



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ANALYSIS OF WAVE HEIGHTS

FOR

TOWN OF DARIEN, FAIRFIELD COUNTY, CONNECTICUT

Prepared by

For

FEDERAL EMERGENCY MANAGEMENT AGENCY

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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
	1.1 Background and Purpose	1
2.0	INVESTIGATIONS	2
	2.1 Previous Studies	2
	2.2 Data Collection and Review	2
	2.3 Wave Height Analysis	3
	2.4 Results	5
3.0	FLOOD PLAIN MANAGEMENT APPLICATIONS	7
	3.1 Flood Boundaries	7
	3.2 Base Flood Elevations	8
	3.3 Velocity Zones	8
4.0	INSURANCE APPLICATION	8
	4.1 Flood Hazard Factors	9
	4.2 Flood Insurance Zones	9
	4.3 Flood Insurance Rate Map	10
5.0	OTHER STUDIES	10
6.0	REFERENCES	10

BEST DOCUMENT AVAILABLE

TABLE OF CONTENTS - continued

Page

FIGURES

Figure 1 - Transect Location Map 4

Figure 2 - Typical Transect Schematic 6

TABLES

Table 1 - Transect Descriptions 5

Table 2 - Flood Insurance Zone Data 10

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1.0 INTRODUCTION

1.1 Background and Purpose

The Federal Emergency Management Agency (FEMA) recently adopted recommendations by the National Academy of Sciences to include prediction of wave heights in Flood Insurance Studies for coastal communities subject to storm surge flooding, and to report the estimated wave crest elevations as the base flood elevations on Flood Insurance Rate Maps (FIRMs).

Previously, FIRMs were produced showing only the stillwater storm surge elevations due to the lack of a suitable and generally applicable methodology for estimating the wave crest elevations associated with storm surges. These stillwater elevations were subsequently stipulated in community flood plain management ordinances as the minimum elevation of the lowest floor including basement of new construction. Communities and individuals had to consider the additional hazards of velocity waters and wave action on an ad hoc basis. Because there has been a pronounced tendency for buildings to be constructed only to meet minimum standards, without consideration of the additional hazard due to wave height, increasing numbers of people could unknowingly be accepting a high degree of flood-related personal and property risk in coastal areas subject to wave action. Therefore, the FEMA has pursued the development of a suitable methodology for estimating the wave crest elevations associated with storm surges. The recent development of such a methodology by the National Academy of Sciences has led to the adoption of wave crest elevations for use as the base flood elevations in coastal communities (Reference 1).

The greatest floods of record were caused by heavy rainfall and hurricane winds of tropical origin, resulting in heavy runoff and abnormally high tides. The hurricane of September 1938 was the largest flood recorded in the study area. Since extensive residential development in the Town of Darien occurred after this flood of record, no reports of extensive flood problems or damage exist. During the hurricane of Occane of September 1938 was the largest flood recorded in the study area. Since extensive residential development in the Town of Darien occurred after this flood of record, no reports of extensive flood problems or damage exist. During the hurricane of October 1955, widespread flooding occurred along all of the water courses studied. While this hurricane was not as severe as the September 1938 flood of record, there were many injuries, some fatalities, and extensive property damage as a result of the increased development along the watercourses.

The purpose of this study is to revise the FIRM for the Town of Darien, Fairfield County, Connecticut, to include the effects of wave action for the following flooding source: Long Island Sound.

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2.0 INVESTIGATIONS

2.1 Previous Studies

Storm stillwater elevations used in this analysis were developed by Dewberry and Davis (Reference 2). These elevations were developed by adjusting the elevations of the U. S. Army Corps of Engineers (COE) publication Tidal Profiles for the New England Coastline using an analysis for New London, Connecticut, and profiles for the 1938 and 1954 storm events (References 3 and 4). These elevations supersede the elevations used in the previous Flood Insurance Study for Darien (Reference 5).

2.2 Data Collection and Review

All available source data applicable for the wave height analysis were collected and reviewed. Because wave height calculations are based on such parameters as the size and density of vegetation, natural barriers (sand dunes), buildings, and other manmade structures, it was necessary to obtain detailed information on the physical and cultural features of the study area.

Several sources were contacted for data. Aero Graphics Corporation of Bohemia, New York, was contacted for aerial photographs. The Connecticut Department of Transportation, the Connecticut Department of Public Works, and the Town of Darien were contacted for mapping. The principal source materials used for the wave height analysis are described below.

1. Aerial photographs (steroscopic coverage) of Darien were obtained from Aero Graphics Corporation of Bohemia, New York (Reference 6). These photographs were taken in April 1980, and are at a scale of 1:12,000. They were used to determine the type, size, and density of vegetation and physical features.

2. Detailed topographic maps of the Town of Darien, Connecticut, at a scale of 1:2,400 were obtained from the Department of Highways and Bridges, Darien, Connecticut (Reference 7). These maps were made by Raynor Aerial Surveys of Georgetown, Connecticut, and were published in November 1953. These maps have a contour interval of 5 feet and contain many spot elevations. These maps were used as the work maps for the wave height calculations and for plotting wave elevations and the boundaries of the flood hazard zones (Section 3.1).

3. Stillwater elevations for the storm surges were obtained from the publication, Tidal Flood Profiles for the Connecticut Shoreline of Long Island Sound (Reference 2).

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4. U. S. Geological Survey quadrangles of Stamford, Connecticut, and Norwalk South, Connecticut, were used for the placement of transects and for fetch computations (Reference 8).

2.3 Wave Height Analysis

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 1). This method is based on three major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures described in Reference 1. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

Wave heights were computed along transects (cross section lines) that were located along the coastal areas, as illustrated in Figure 1, in accordance with the Users Manual for Wave Height Analysis (Reference 9). The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

Each transect was taken perpendicular to the shoreline and extended inland to a point where wave action ceased. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect. Table 1 provides a listing of the transect location and stillwater starting elevations, as well as maximum wave crest elevations. All dunes and structures were assumed to remain intact for purposes of this analysis.

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

TOWN OF DARIEN, CT
(FAIRFIELD CO.)

APPROXIMATE SCALE
2000 0 2000 4000 6000 FEET

TRANSECT LOCATION MAP

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TABLE 1 - TRANSECT DESCRIPTIONS

Transect	Location	Elevation (feet) Stillwater 100-year	Elevation (feet) Maximum Wave Crest 100-year
No. 1	Noroton River to Brush Island Road, extended	11.4	17
No. 2	Brush Island Road, extended, to Short Lane, extended	11.4	17
No. 3	Short Lane, extended, to Pratt Island	11.4	17
No. 4	Shoreline of Pratt Island	11.4	17
No. 5	Plymouth Road, extended, to Darien River	11.4	15
No. 6	Darien River to Long Neck Point	11.4	17
No. 7	Long Neck Point to Great Island	11.4	17
No. 8	Shoreline of Scotts Cove	11.4	16
No. 9	Shoreline of Contentment Island	11.4	16
No. 10	Butlers Island Road, extended, to Fivemile River	11.4	17

Figure 2 is a profile for a typical transect illustrating the effects of energy dissipation and regeneration on a wave as it moves inland. This figure shows the wave elevations being decreased by obstructions, such as buildings, vegetation, and rising ground elevations, and being increased by open, unobstructed wind fetches. Actual wave conditions in the Town of Darien may not include all the situations illustrated in Figure 2.

After analyzing wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including the aerial photographs, topographic maps, and engineering judgment. Controlling features affecting the elevations were identified and considered in relation to their positions at a particular transect and their variation between transects.

2.4 Results

Computed wave heights and elevations associated with the 100-year storm surge are summarized below for various reaches in the study area.

Long Island Sound (Transects 1-10)

Wave action associated with the 100-year storm surge from Long Island Sound affects the entire Darien shoreline, Holly Pond, Darien River, Scott Cove, and Fivemile River. The maximum wave crest elevation from Long Island Sound is 17 feet.

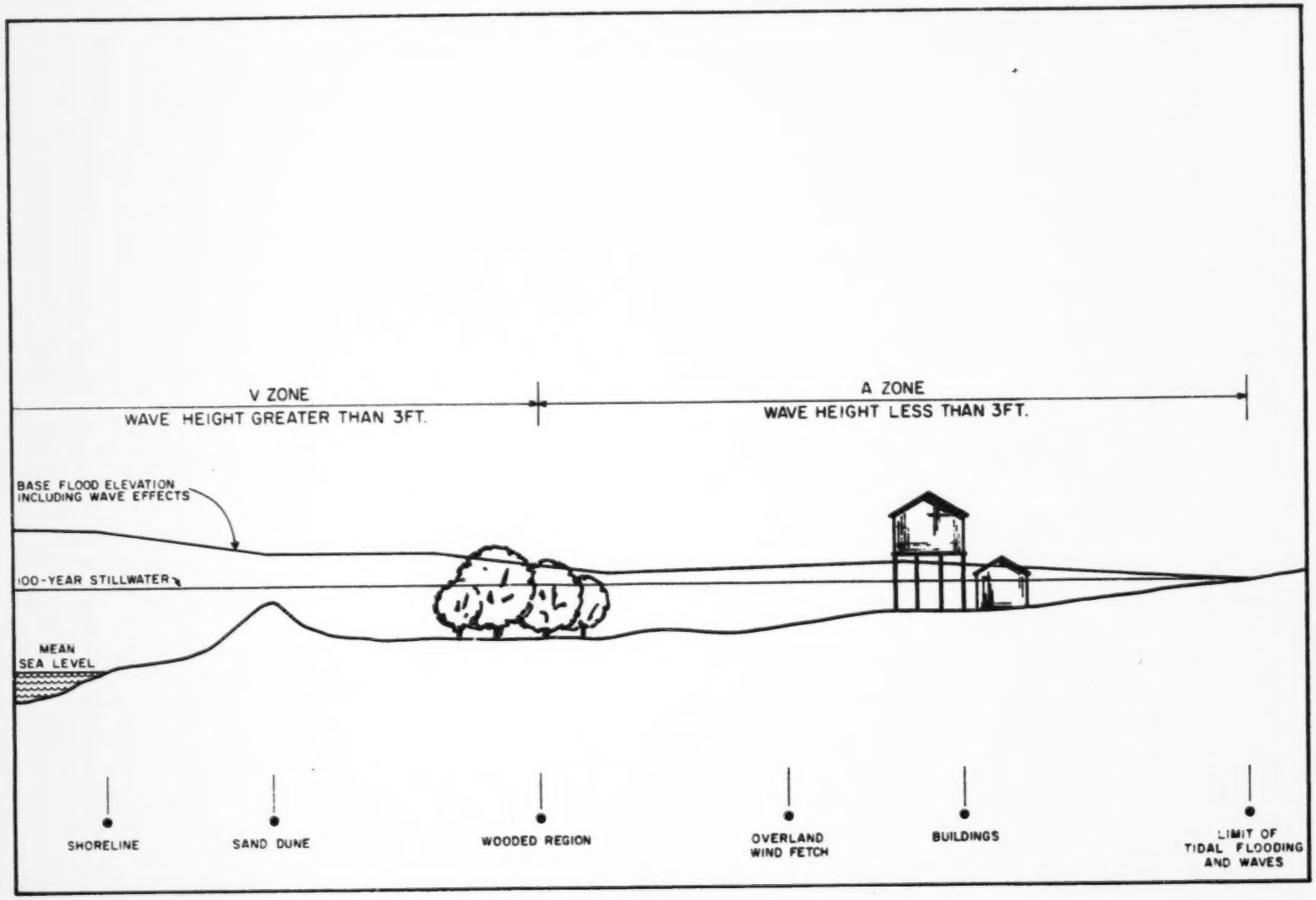

FIGURE 2
TYPICAL TRANSECT SCHEMATIC

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The sharp rise along most of the shoreline in the community precludes any significant wave action associated with the 100-year surge. However, there are some lowland areas of the community where waves propogate inland significantly. In the east end of the community, waves greater than three feet extend inland approximately 0.5 miles south of Tokeneke Point Road, and waves less than three feet propogate up to Tokeneke Point Road. Waves greater than three feet propogate across the low lying marsh area around Scott Cove and Hay Island, and are diminished to less than three feet by the rise of ground elevation that extends beyond the marsh. Waves less than three feet propogate up the Darien River until the elevation from the river flooding becomes more important. Waves greater than three feet from Holly Pond affect the low lying areas of Brush Island up to the higher ground elevation around Near Water Lane.

On September 29, 1981, the results of this study were reviewed at a final Consultation and Coordination Officer's (CCO) meeting attended by representatives of the FEMA, the Town of Darien, and Dewberry & Davis.

3.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

A prime purpose of the National Flood Insurance Program is to encourage local governments to adopt sound flood plain management programs designed to reduce future flood losses. The FIRM for the Town of Darien has been revised to incorporate the latest available information, including wave height data, to assist these communities in developing the most appropriate and effective flood plain management measures.

3.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the FEMA as the base flood for purposes of flood plain management. This flood has a 1 percent chance of being equalled or exceeded each year and is expected to be exceeded once on the average during any 100-year period. The risk of having a flood of this magnitude or greater increases when periods longer than 1 year are considered. For example, over a 30-year period, there is a 26 percent chance of experiencing a flood equal to or greater than the 100-year flood. The 500-year flood plain is also shown on the FIRM to indicate areas of moderate flood hazards.

Areas inundated by the 100-year flood are shown as A and V Zones on the community's FIRM. It is in these areas that the FEMA requires local communities to exercise flood plain management measures as a condition for participation in the National Flood Insurance Program.

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3.2 Base Flood Elevations

Areas within the communities studied by detailed engineering methods have base flood elevations established in A and V Zones. These are the elevations of the base (100-year) flood relative to the National Geodetic Vertical Datum (mean sea level) of 1929. In coastal areas affected by wave action, base flood elevations are generally maximum at the normal open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the FIRMs. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. Base flood elevations shown in the wave action areas represent the average elevation within the zone. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the base flood elevation in A and V Zones.

3.3 Velocity Zones

The COE has established the 3-foot breaking wave as the criterion for identifying coastal high hazard zones (Reference 10). This was based on a study of wave action effects on structures. This criterion has been adopted by the FEMA for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program regulations require much more stringent flood plain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations.

The location of the V Zone is determined by the 3-foot breaking wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 100-year flood depth is insufficient to support a 3-foot breaking wave.

4.0 INSURANCE APPLICATIONS

The assignment of proper actuarial insurance rates requires that frequency and depth of flooding be estimated as accurately as possible. Because waves can add considerably to expected flood depths, it is important that insurance rates consider this additional hazard. The FEMA has developed a process to transform the data from this study into flood insurance criteria. This process includes the determination of Flood Hazard Factors and the designation of flood insurance zones.

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4.1 Flood Hazard Factors

The Flood Hazard Factor (FHF) is the device used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHF are used to set actuarial insurance premium rate tables.

The FHF is shown as a three-digit code that expresses the difference between the 10- and 100-year flood elevations to the nearest 0.5 foot. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year water-surface elevations is greater than 10.0 feet, the FHF is computed to the nearest foot.

4.2 Flood Insurance Zones

After wave elevations for the 100-year storm surge were determined and mapped, the study areas were divided into zones, each having a specific flood potential and FHF. Each zone was assigned one of the following flood insurance zone designations:

Zone V6: Special Flood Hazard Areas along coasts inundated by the 100-year flood as determined by detailed methods, and that have additional hazards due to velocity (wave action); base flood elevations shown, and zones subdivided according to FHFs.

Zone A6: Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHF.

Zone B: Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; also, areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.

Zone C: Areas of minimal flooding.

Table 2, "Flood Insurance Zone Data", summarizes the FHFs, flood insurance zones, and base flood elevations for the flooding source in the study area.

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TABLE 2 - FLOOD INSURANCE ZONE DATA

Flooding Source	Stillwater Elevation 10-Year	50-Year	100-Year	500-Year	FHF	Zone	Base Flood Elevation (Feet NGVD)*
Long Island Sound Transects 1-10	8.4	10.9	11.4	12.6	030	V6	14-17
					030	A6	11-13

*Due to map scale limitations, base flood elvations shown on the FIRM may represent average elevations for the zones depicted.

4.3 Flood Insurance Rate Map

After flood insurance zones were established for the study area, the FIRM for the Town of Darien was revised to incorporate the new zone information. This map contains the official delineation of flood insurance zones and base flood elevations.

The base map for the three panels along the coastline has been changed using the work maps for this wave height analysis. This change was made to coordinate the flood boundaries with the base map.

5.0 OTHER STUDIES

Flood Insurance Rate Maps for the adjacent City of Stamford are being revised concurrently with this study to include Wave Height Analysis (Reference 11). The revised study for Stamford will be in agreement with this Wave Height Analysis for the Town of Darien.

6.0 REFERENCES

1. National Academy of Sciences, Methodology for Calculating Wave Action Effects Associated With Storm Surges, Washington, D. C., 1977.

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